

WHAT IS CLAIMED IS:

1. A phase-locked loop circuit for use in a programmable logic device, said phase-locked loop circuit having an input terminal for receiving an input signal having a reference frequency and an output terminal for  
5 outputting an output frequency phase-locked to said reference frequency, and comprising:  
an oscillator for producing said output frequency; and  
a feedback path feeding said oscillator,  
10 said feedback path accepting as inputs said reference frequency and said output frequency, and causing said oscillator to drive said output frequency to a phase-frequency lock with said reference frequency, said feedback path comprising at least one component connected  
15 therein; wherein:  
at least one of said at least one component is also connected to another portion of said programmable logic device for operation of said another portion of said programmable logic device with said at least one of said  
20 at least one component.
2. The phase-locked loop circuit of claim 1 wherein, when said phase-locked loop circuit is not in use in said programmable logic device, said at least one of said at least one component is available for use by said  
5 another portion of said programmable logic device.
3. The phase-locked loop circuit of claim 1 wherein, when said phase-locked loop circuit is in use in said programmable logic device, said another portion of said programmable logic device is available to be  
5 substituted in said phase-locked loop circuit for said at least one of said at least one component.
4. The phase-locked loop circuit of claim 1 wherein said at least one component comprises:

a phase-frequency detector having as inputs  
said reference frequency and said output frequency, said  
5 phase-frequency detector outputting a comparison signal  
indicating a relationship between said reference frequency  
and said output frequency;

an analog front end circuit having said  
comparison signal as an input and outputting an analog  
10 voltage signal indicative of said comparison;

an analog-to-digital converter having said  
analog voltage signal as an input and outputting a  
digitized voltage signal;

a digital signal processor having said  
15 digitized voltage signal as an input and outputting a  
digital control signal; and

a digital-to-analog converter having said  
digital control signal and outputting an analog control  
signal that is input to said oscillator.

5. The phase-locked loop circuit of claim 4  
wherein said analog-to-digital converter has at least one  
of:

a second input from a first said another  
5 portion of said programmable logic device; and

a second output to a second said another  
portion of said programmable logic device.

6. The phase-locked loop circuit of claim 5  
wherein said first said another portion is a pin of said  
programmable logic device.

7. The phase-locked loop circuit of claim 5  
wherein said first said another portion is in core logic  
of said programmable logic device.

8. The phase-locked loop circuit of claim 5  
wherein said second said another portion is a pin of said  
programmable logic device.

9. The phase-locked loop circuit of claim 5 wherein said second said another portion is in core logic of said programmable logic device.

10. The phase-locked loop circuit of claim 4 wherein said digital signal processor has at least one of:  
a second input from a first said another portion of said programmable logic device; and

5 a second output to a second said another portion of said programmable logic device.

11. The phase-locked loop circuit of claim 10 wherein said first said another portion is a pin of said programmable logic device.

12. The phase-locked loop circuit of claim 10 wherein said first said another portion is in core logic of said programmable logic device.

13. The phase-locked loop circuit of claim 10 wherein said second said another portion is a pin of said programmable logic device.

14. The phase-locked loop circuit of claim 10 wherein said second said another portion is in core logic of said programmable logic device.

15. The phase-locked loop circuit of claim 4 wherein said digital-to-analog converter has at least one of:

5 a second input from a first said another portion of said programmable logic device; and

a second output to a second said another portion of said programmable logic device.

16. The phase-locked loop circuit of claim 15 wherein said first said another portion is a pin of said programmable logic device.

17. The phase-locked loop circuit of claim 15 wherein said first said another portion is in core logic of said programmable logic device.

18. The phase-locked loop circuit of claim 15 wherein said second said another portion is a pin of said programmable logic device.

19. The phase-locked loop circuit of claim 15 wherein said second said another portion is in core logic of said programmable logic device.

20. The phase-locked loop circuit of claim 4 wherein said analog front end circuit comprises a charge pump.

21. The phase-locked loop circuit of claim 1 wherein said at least one component comprises:

5 a phase-frequency detector having as inputs said reference frequency and said output frequency, said phase-frequency detector outputting digital comparison signals indicating a relationship between said reference frequency and said output frequency;

10 a digital counter circuit having said digital comparison signals as inputs and outputting digital count signals indicative of said comparison;

a digital signal processor having said digital count signals as inputs and outputting a digital control signal; and

15 a digital-to-analog converter having said digital control signal and outputting an analog control signal that is input to said oscillator.

22. The phase-locked loop circuit of claim 21 wherein said digital signal processor has at least one of:

an additional input from a first said another portion of said programmable logic device; and

5 a second output to a second said another portion of said programmable logic device.

23. The phase-locked loop circuit of claim 22 wherein said first said another portion is a pin of said programmable logic device.

24. The phase-locked loop circuit of claim 22 wherein said first said another portion is in core logic of said programmable logic device.

25. The phase-locked loop circuit of claim 22 wherein said second said another portion is a pin of said programmable logic device.

26. The phase-locked loop circuit of claim 22 wherein said second said another portion is in core logic of said programmable logic device.

27. The phase-locked loop circuit of claim 21 wherein said digital-to-analog converter has:

- a second input from a first said another portion of said programmable logic device; and
- 5 a second output to a second said another portion of said programmable logic device.

28. The phase-locked loop circuit of claim 27 wherein said first said another portion is a pin of said programmable logic device.

29. The phase-locked loop circuit of claim 27 wherein said first said another portion is in core logic of said programmable logic device.

30. The phase-locked loop circuit of claim 27 wherein said second said another portion is a pin of said programmable logic device.

31. The phase-locked loop circuit of claim 27 wherein said second said another portion is in core logic of said programmable logic device.

32. The phase-locked loop circuit of claim 1 wherein said oscillator is a voltage-controlled oscillator.

33. The phase-locked loop circuit of claim 1 further comprising an output scaling counter downstream of said output terminal.

34. The phase-locked loop circuit of claim 1 further comprising an input scaling counter upstream of said input terminal.

35. The phase-locked loop circuit of claim 1 further comprising a feedback scaling counter between said output terminal and said feedback path.

36. A programmable logic device comprising the phase-locked loop circuit of claim 1.

37. A digital processing system comprising:  
processing circuitry;  
a memory coupled to said processing  
circuitry; and

5 a programmable logic device as defined in claim 36 coupled to the processing circuitry and the memory.

38. A printed circuit board on which is mounted a programmable logic device as defined in claim 36.

39. The printed circuit board defined in claim 38 further comprising:

memory circuitry mounted on the printed  
circuit board and coupled to the programmable logic  
5 device.

40. The printed circuit board defined in claim 39 further comprising:

processing circuitry mounted on the printed  
circuit board and coupled to the memory circuitry.

41. An integrated circuit device comprising the phase-locked loop circuit of claim 1.

42. A digital processing system comprising:  
processing circuitry;  
a memory coupled to said processing  
circuitry; and

5 an integrated circuit device as defined in  
claim 41 coupled to the processing circuitry and the  
memory.

43. A printed circuit board on which is mounted  
an integrated circuit device as defined in claim 41.

44. The printed circuit board defined in claim  
43 further comprising:

memory circuitry mounted on the printed  
circuit board and coupled to the integrated circuit  
5 device.

45. The printed circuit board defined in claim  
44 further comprising:

processing circuitry mounted on the printed  
circuit board and coupled to the memory circuitry.

46. A programmable logic device comprising:  
at least one programmable logic region; and  
a phase-locked loop circuit having an input  
terminal for receiving an input signal having a reference  
5 frequency and an output terminal for outputting an output  
frequency phase-locked to said reference frequency, and  
comprising:

an oscillator for producing said output  
frequency, and

10 a feedback path feeding said oscillator,  
said feedback path accepting as inputs said reference  
frequency and said output frequency, and causing said  
oscillator to drive said output frequency to a phase-  
frequency lock with said reference frequency, said

15 feedback path comprising at least one component connected  
therein, wherein:

at least one of said at least one component  
is also connected to said programmable logic region for  
operation of said programmable logic region with said at  
20 least one of said at least one component.

47. The programmable logic device of claim 46  
wherein, when said phase-locked loop circuit is not in use  
in said programmable logic device, said at least one of  
said at least one component is available for use by said  
5 at least one programmable logic region.

48. The programmable logic device of claim 46  
wherein, when said phase-locked loop circuit is in use in  
said programmable logic device, at least a portion of said  
at least one programmable logic region is available to be  
5 substituted in said phase-locked loop circuit for said at  
least one of said at least one component.

49. The programmable logic device of claim 46  
wherein said at least one component comprises:

a phase-frequency detector having as inputs  
said reference frequency and said output frequency, said  
5 phase-frequency detector outputting a comparison signal  
indicating a relationship between said reference frequency  
and said output frequency;

an analog front end circuit having said  
comparison signal as an input and outputting an analog  
10 voltage signal indicative of said comparison;

an analog-to-digital converter having said  
analog voltage signal as an input and outputting a  
digitized voltage signal;

a digital signal processor having said  
15 digitized voltage signal as an input and outputting a  
digital control signal; and

a digital-to-analog converter having said  
digital control signal and outputting an analog control  
signal that is input to said oscillator.



50. The programmable logic device of claim 49 wherein said analog-to-digital converter has at least one of:

5 a second input from a first said another portion of said programmable logic device; and

a second output to a second said another portion of said programmable logic device.

51. The programmable logic device of claim 50 wherein said first said another portion is a pin of said programmable logic device.

52. The programmable logic device of claim 50 wherein said first said another portion is in core logic of said programmable logic device.

53. The programmable logic device of claim 50 wherein said second said another portion is a pin of said programmable logic device.

54. The programmable logic device of claim 50 wherein said second said another portion is in core logic of said programmable logic device.

55. The programmable logic device of claim 49 wherein said digital signal processor has at least one of:

5 a second input from a first said another portion of said programmable logic device; and

a second output to a second said another portion of said programmable logic device.

56. The programmable logic device of claim 55 wherein said first said another portion is a pin of said programmable logic device.

57. The programmable logic device of claim 55 wherein said first said another portion is in core logic of said programmable logic device.

58. The programmable logic device of claim 55 wherein said second said another portion is a pin of said programmable logic device.

59. The programmable logic device of claim 55 wherein said second said another portion is in core logic of said programmable logic device.

60. The programmable logic device of claim 49 wherein said digital-to-analog converter has at least one of:

- a second input from a first said another  
5 portion of said programmable logic device; and
- a second output to a second said another  
portion of said programmable logic device.

61. The programmable logic device of claim 60 wherein said first said another portion is a pin of said programmable logic device.

62. The programmable logic device of claim 60 wherein said first said another portion is in core logic of said programmable logic device.

63. The programmable logic device of claim 60 wherein said second said another portion is a pin of said programmable logic device.

64. The programmable logic device of claim 60 wherein said second said another portion is in core logic of said programmable logic device.

65. The programmable logic device of claim 49 wherein said analog front end circuit comprises a charge pump.

66. The programmable logic device of claim 46 wherein said at least one component comprises:  
a phase-frequency detector having as inputs  
said reference frequency and said output frequency, said

5 phase-frequency detector outputting digital comparison  
signals indicating a relationship between said reference  
frequency and said output frequency;  
a digital counter circuit having said  
digital comparison signals as inputs and outputting  
10 digital count signals indicative of said comparison;  
a digital signal processor having said  
digital count signals as inputs and outputting a digital  
control signal; and  
a digital-to-analog converter having said  
15 digital control signal and outputting an analog control  
signal that is input to said oscillator.

67. The programmable logic device of claim 66  
wherein said digital signal processor has at least one of:  
an additional input from a first said  
another portion of said programmable logic device; and  
5 a second output to a second said another  
portion of said programmable logic device.

68. The programmable logic device of claim 67  
wherein said first said another portion is a pin of said  
programmable logic device.

69. The programmable logic device of claim 67  
wherein said first said another portion is in core logic  
of said programmable logic device.

70. The programmable logic device of claim 67  
wherein said second said another portion is a pin of said  
programmable logic device.

71. The programmable logic device of claim 67  
wherein said second said another portion is in core logic  
of said programmable logic device.

72. The programmable logic device of claim 66  
wherein said digital-to-analog converter has:  
a second input from a first said another  
portion of said programmable logic device; and

5                   a second output to a second said another portion of said programmable logic device.

73. The programmable logic device of claim 72 wherein said first said another portion is a pin of said programmable logic device.

74. The programmable logic device of claim 72 wherein said first said another portion is in core logic of said programmable logic device.

75. The programmable logic device of claim 72 wherein said second said another portion is a pin of said programmable logic device.

76. The programmable logic device of claim 72 wherein said second said another portion is in core logic of said programmable logic device.

77. The programmable logic device of claim 46 wherein said oscillator is a voltage-controlled oscillator.

78. The programmable logic device of claim 46 further comprising an output scaling counter downstream of said output terminal.

79. The programmable logic device of claim 46 further comprising an input scaling counter upstream of said input terminal.

80. The programmable logic device of claim 46 further comprising a feedback scaling counter between said output terminal and said feedback path.

81. A digital processing system comprising:  
processing circuitry;  
a memory coupled to said processing  
circuitry; and

5                   a programmable logic device as defined in  
claim 46 coupled to the processing circuitry and the  
memory.

82. A printed circuit board on which is mounted  
a programmable logic device as defined in claim 46.

83. The printed circuit board defined in claim  
82 further comprising:

memory circuitry mounted on the printed  
circuit board and coupled to the programmable logic  
5 device.

84. The printed circuit board defined in claim  
83 further comprising:

processing circuitry mounted on the printed  
circuit board and coupled to the memory circuitry.